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ABSTRACT

This paper investigates the meanings of the word "chance" in adult education. A questionnaire for assessing the level of probability understanding was administered to students in three countries--Canada, Brazil, and Hungary. Of the 18 questions on the questionnaire, four concerned language use. This paper reports on data relative to one of those questions. Students were asked to write a sentence ending with "É is something that happens by chance." The analysis found that students may have very unorthodox uses for the word "chance" and that until it is determined what students actually think chance is, there is little chance of influencing them toward using probability theory. (MVL)

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Different Interpretations of Chance by Brazilian Adults

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Editor's Note: This paper reports on an important line of research that was very dear to the heart and mind of Dr. José Elias Damasceno. His questioning and plans for future research were suddenly stopped when, after a brief illness, he died on August 24, 2000, at the age of 39. At his burial service his scientific spirit was highly praised by his colleagues, who are honored to have known him and deeply miss him.

It is somewhat of a challenge that this paper will be written in English. Why? Because the English word *chance* has at least two very distinct meanings. And while if we were using another language we might have two different words available, one for each of the two different meanings we may wish to communicate, in English we will have to use the word *chance* indiscriminately.

This certainly is not a limitation, for we are sure that the reader is able to distinguish between the two meanings, even though he or she may be used to seeing them denoted by the same word *chance*, sometimes even in the same paragraph, as below:

> Chance opens the door to luck. When the chances are against success and it nevertheless occurs, you are lucky. Conversely, if the chances favor success and nevertheless it fails to ensue, you are unlucky. (Rescher, 1995, p. 42)

In the first sentence of the quote, the word "chance" is used to denote something that can be thought of as having real and objective status. In the sentences that follow, "the chances" are "the odds," or measurements of probability.

Chance in the title of this article is intended to have the first meaning mentioned above: not a measure of probability, as in "the chance that the flip of a coin yields tails is ½," but a representation of "some distinct creative or administrative agency" (Venn, 1888, p. 235), the same as *acaso* in Portuguese, or *hazard* in French.

But why bother with such a highly philosophical concept, one that touches at centuries-old questions such as those about free will versus predetermination or about the appropriateness of the assumptions we make about causality and indeterminism in science?

Our decision to pursue this investigation arose from the confluence of several of our research interests:

- We are convinced of the influence of students' cultural backgrounds in their learning of mathematics. People's beliefs and worldviews, especially in the case of adults, are the frames on which they are going to construct new mathematical concepts. And one aspect of culture is particularly important: the language in which students think and receive new information.
- We understand that the comprehension of the concept of chance, as well as the learning of probability, should be a goal for our students. Although chance and probability are conceptually independent concepts (von Plato, 1982), the concept of chance permeates probabilistic thought and therefore deserves the attention of educators.

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Meanings of Chance

The words chance and fortune have been part of the philosophical vocabulary since Aristotle, and while the Greeks had a Goddess of Chance, the objection against the existence of chance is also very old (Venn, 1888; Gigerenzer et al., 1989). The question of whether an event should be attributed to chance or to causation is a philosophical enquiry that has attracted a lot of popular attention, too, and is often part of the questionings of non-academics as well.

Some of the meanings of chance identified in everyday language by Ayer (1965) are:

- An event is said to occur by chance when no one intended it to happen. In other words, it is an undesigned, but not necessarily uncaused, event.
- A chance event is due to the concurrence or coincidence in time or place of events belonging to causally independent series. One would cease to attribute the event to chance if the concurrences happen repeated times.
- A chance event is one that has an *a priori* probability of occurring. There is no implication that the event is uncaused.

Relationship Between Chance and Probability

Different literatures present contradictory views on the relationship between probability and chance. This has direct implications for education.

In Piaget's view, the idea of chance is a prerequisite for the development of the understanding of probability (Piaget, 1974). A historical analysis, however, indicates that a working knowledge of probabilities does not necessarily entail the embracing of the currently normative concept of chance.

At the birth of probability theory the aspect that became most evident in philosophical discussions of chance was its opposition to divine purpose. The very mathematicians who proposed a place for chance in the natural and moral sciences maintained that what we called chance was mere ignorance of the true causes of an event and that every event was governed by necessary causes, even if hidden or unknown (Hacking, 1990). Probability theory would then, for these theorists, be useful for us because of our ignorance and limitations. Eminent mathematicians such as Jakob Bernoulli and Laplace maintained that if we knew all necessary causes we would be able to predict every event and would have no need for probabilities. Needless to say, these mathematicians were experts on the calculus of probabilities, hinting at the independence between the philosophical stance and the mastery of the theory.

The Piagetian view is also opposed by Metz (1993), who examined kindergartners' and third graders' chance, probabilistic, and alternative interpretations in a spinner's task. She categorized children's manifestations of interpretations of the spinner's outcome into the categories *Probability without Chance*, *Chance without Probability*, and *Chance with Probability*, as well as into two other categories for spurious interpretations, finding results that violated Piaget's model: 23% of the kindergartners and 28% of the third graders exhibited Probability without Chance, whereas Chance without Probability was rare at both grade levels. Metz concluded that people have difficulty in conceptualizing the source of the variability of results of events, the bounds of the predictable, and the bounds of control.

This common difficulty is a challenge that we propose to face, by seeking first to understand what people think the sources of common events are, and how they interpret the role of chance in them, so that we can later move toward the incorporation of discussions on variability, control, predictability, causation, and chance into the curriculum. For this objective, it is imperative that we investigate the usage of the language related to chance among the populations we will be serving (Freire, 1968).

The Study

The conclusions reported in this paper refer to data collected as part of a research project involving students in Brazil, Canada (Quebec), and Hungary, the SIMULO project. A questionnaire, mostly based on Green's (1982)

instrument for assessing the level of probability understanding, was administered to students in the three countries, with the objective of selecting students with various levels of probability thinking for a study on modeling and simulation. Of the 18 questions of the questionnaire, four concerned language use. In this paper we report our conclusions about data relative to one of these questions, answered by 63 students in the 18-26 age range.

In the activity in question, students were to write a sentence ending with "... is something that happens by chance." Since, in the larger context, one of the aims of the study was to investigate linguistic issues in probabilistic thinking, with this assignment we not only wanted students to give examples of events that they thought were ruled by chance, but also wanted to know how they used the expression "by chance" in everyday language. So instead of just asking students to give examples of chance events, we shaped some activities in the original study to assess language use.

Our first thought was to fit the data into four categories: deterministic, probabilistic, nonsensical, or blank, according to the nature of the students' answers. Immediately afterwards we realized those categories were not good for data arising from the question we posed to students. In simplistic terms, a deterministic stance is one in which causes are attributed to every event. Giving as an example of chance events one that clearly has a chain of causes related to it does not characterize a deterministic point of view but, rather, a personalistic perception of chance. Moreover, the classification above, besides being very hard to code reliably, would bring little if any clarification into the language issues we sought to investigate. We then decided to create new categories, according to what we thought were significantly similar interpretations of chance among some of the students' answers: chance as justification for unfortunate events and chance related to events of very small frequency.

Chance as Justification for Unfortunate Events.
A large number of answers dealt with unfortunate or undesirable events. Many of those events had evident causes that were often even explicit in the sentences, but chance was apparently used to console someone or oneself. Notice that we are not saying that students conceptualized chance as something that rules unfortunate events, or saying that only bad things happen by chance, but that they were *using* the term chance and the idea of chance as a justification for undesired outcomes, or even as a way to diminish bad feelings about the events. The examples below illustrate this:

> "To get a bad grade in the math test...(is something that happens by chance)."
> "To be barred at the door because I was not wearing the uniform..."
> "A pregnant woman wants a male son and a baby girl is born..."
> "Don't worry. Your father will come back. This is ..."
> "To be late to school ..."
> "Getting bad grades in subjects I study hard..."

It was for us so surprising to see this type of sentence be given in response to the request to build a phrase ending with "is something that happens by chance" that we had to look for a different interpretation of them. This was when we came up with this category, and suddenly a large number of answers started to make sense. With this interpretation, the first sentence would be saying "I got a bad grade in the math test. It is bad, but it is OK, these things happen (by chance)." The sentence "Don't worry, your father will come back" could thus be understood as "Something chancy may have delayed him, but he (and you) will be OK." Or, referring to the last example, "Getting bad grades in subjects I study hard is something bad, but it happens (by chance)." And maybe: "Thus I shouldn't feel so bad about it."

Chance Related to Events of Very Small Frequency
Another class of answers made no apparent sense as examples of chance events, but started to make sense once we realized they all had a common feature: they dealt with events of very small probability—or at least would make more sense if we assume the events are very infrequent. For example:

"Seeing my father in a good mood..."
"Getting a good grade in Portuguese..."
"An improbable happening..."
"A poor person become rich, a rich person share with the poor..."
"Finding the principal at the school..."
"A garbage collector becoming the manager of the Urban Garbage Collection Service..."
"Having an education and being well accepted in today's society..."
"Having a liberal principal..."
"Sleeping during the afternoon, for me..."
"It is very unlikely that this happens, because..."
"Yesterday I went out..."

In our interpretation, giving the sentence "Yesterday I went out" in response to the activity proposed could make sense if this happened very infrequently and the person uses the expression "is something that happens by chance" to mean "is something very infrequent." According to this interpretation, the first example would mean "my father is rarely in a good mood." Other answers suggest this category even more clearly, like the one: "It is very unlikely that this happens, because this is something that happens by chance." This sentence definitely does not make sense if we hold on to the usual concept of chance, for an event may be ruled by chance and still have high probability of happening, such as "getting a number different than one in the roll of a die," which has probability 5/6.

Discussion

The analysis above points out that students may have very unorthodox uses for the word chance. We believe that idiosyncratic language and the meanings it conveys must be known by us before we attempt to influence students toward the application of probability theory in everyday matters. We agree with Humphreys (1989) when he says that it would be unfortunate if a psychological prejudice in favor of fate or some unusual conception of chance prevented students from an objective evaluation of a probabilistic theory. Even if we cannot argue against philosophical or religious stances, one way to deal with this matter in class is, as Humphreys proposes to do in his discussion of indeterminism in *The Chances of Explanation*, to design a polemic to undermine prejudices.

Prior to designing such a polemic, however, we need to be well informed about what conceptions our students have of chance. Our research program parallels that of Cohen (1973) in his study of what he calls "psychological probabilities." His justification for his endeavor can then add meaning to what we are striving to do. Cohen emphasizes that the probability of which he speaks is not to be confused with the varieties of subjective probability in its axiomatic treatment. While the subjective interpretations of probability (those of different subjectivist schools) carry a prescriptive character, that is, describe how an ideal person would reason hoping that real people can apply those norms to their own reasoning, Cohen's psychological probabilities describe the thought of real people, who make mistakes and do not reason in the normative way. He argues that until we have a well-documented natural history of human error, such as the study of psychological probability can give us, the contribution that the subjectivist school can make toward the elimination of human error will be rather limited. We too think that until we bring into discussion what our actual students think chance is, we will have little chance of influencing them toward using probability theory.

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